Saskatchewan Environment

Status and Conservation Management Framework for Woodland Caribou (Rangifer tarandus caribou) in Saskatchewan.

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Fish and Wildlife Technical Report 2003-03

By:
A.A. Arsenault
Provincial Wildlife Population Biologist

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December 2003

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Executive Summary

This document establishes a baseline for woodland caribou population status, distribution, and critical habitat in Saskatchewan through a review of the scientific literature, summary and analysis of existing population data, and delineation of caribou meta-populations on an area specific basis. The purpose of this document was to assist the Woodland Caribou Advisory Team and Woodland Caribou Working Group in development of a recovery action plan for woodland caribou in Saskatchewan.

A management-by-objective (MBO) approach was used to create a biological and ecological framework (Woodland Caribou Management Units (WCMU)) to organize and summarize available data, to provide a structure from which recovery planning and long-term management of woodland caribou can be developed on an area-specific (management unit) basis, and to provide a foundation from which management prescriptions can be evaluated and adjusted as new information is gained (adaptive management).

Woodland caribou are the only ungulate in Saskatchewan that naturally occurs at low densities, has a low reproduction rate, and whose status is threatened both provincially and nationally. They are vulnerable to habitat change because of their dependence on large areas of undisturbed climax habitat and lichens, and fragility with respect to even minor changes in population limiting factors. The provincial population is estimated to be 4,250 animals. The management strategies developed for individual WCMUs in a recovery action plan will be a function of the cumulative effects of habitat alteration and fragmentation in relation to their effect on population limiting factors in each WCMU, and subsequent changes to risk of local population extinction.

Management approaches in recovery action planning should occur at several levels. A coarse scale (ecosystem-based management) approach is a landscape planning approach to natural resource management intended to maintain biodiversity and ecosystem integrity. At the landscape level, this approach relates to the mix of ecosystems in the planning landscape relative to historic conditions. At the ecosystem (stand) level, this approach relates to the spatial and temporal scales over which habitat is altered by industry in relation to the scales and periods that these stands are used by caribou. At the species level, this approach relates to the viability and population parameters in the planning landscape relative to the same measures in historic range. But, woodland caribou populations are limited not only by habitat, but also by a variety of other factors including hunting, and direct and indirect human effects on the landscape that increase mortality rates. Therefore, a fine scale (population management) approach is also needed to assess changes in population dynamics in relation to the anthropomorphic influences on population status (eg. change in management prescription, industrial impacts, direct and indirect effects on the planning landscape).

Management of boreal caribou in Saskatchewan requires weighing the risks and threats of various population limiting factors, with caribou conservation needs. These metrics vary by WCMU and ecozone, which results in differential risk assessment and management prescription by WCMU and ecozone. WCMU populations at highest risk are those with the highest human activity occurring on them. If woodland caribou are to be maintained in perpetuity, it is necessary to determine whether recovery strategies for a particular WCMU are intended for "survival" or "recovery". This will also depend on what portions of the planning landscape have first priority for caribou conservation.

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1.0 Introduction

The purpose of this document is to:

- Establish a baseline for caribou population status, distribution, and critical habitat through a review of the scientific literature, summary and analysis of existing population data, and identification and distribution of woodland caribou meta-populations on an area specific basis (Woodland Caribou Management Unit).

- Create a biological and ecological framework for the long-term management of woodland caribou using a management-by-objective (MBO) approach. This framework is intended to assist the Saskatchewan Woodland Caribou Advisory Team, and Woodland Caribou Working Group in development of a recovery action plan and conservation strategies for woodland caribou.

This report attempts to place woodland caribou conservation within the broader context of provincial objectives of ecosystem-based management, maintenance of biological diversity, and integrated/sustainable use of wildlife. This was accomplished by:

- Focusing on long-term population management with the objective of woodland caribou conservation, without negatively affecting the ecological integrity and biological diversity of the habitats they occupy (ie. conservation issues).

- Improving the scientific knowledge of woodland caribou and their ecological requirements by reviewing the scientific literature, and population data in Saskatchewan.

- Integrating scientific and local knowledge of woodland caribou.

- Developing a conservation framework (Woodland Caribou Management Units) based on meta-population distribution (as determined through sightings, track, and telemetry data, and local knowledge) and the ecological land classification presented by Acton et al. (1998), as well as guidance by SE's policy framework, corporate mandate, and legal obligations.

- Using the best available scientific and local knowledge as a foundation for decision-making.

The problem confronting woodland caribou conservation within the broader context of ecosystem-based management and sustainable use of wildlife is how to balance the needs of managing this species within a broad-level multi-resource management system with competing interests and trade-offs.

2.0 General Description

2.1 Taxonomy

Caribou are members of the order Artiodactyla (cloven-hoofed ruminants), family Cervidae (deer family). The paraxonic foot structure is diagnostic of the order (ie. Plane of symmetry passes between digits three and four). The third and fourth digits bear the animal's weight, the first digit is missing in living members of this order, and the second and fifth digits (dew claws) are reduced in size (Vaughan 1985). Recognized characteristics of North American Cervidae include deciduous antlers (males only and female caribou), four chambered stomachs, and ruminant metabolism (Vaughan 1985). The reindeer of northern Europe and Asia and the caribou of North America are considered members of the same species, *Rangifer tarandus* (Linnaeus) (Banfield 1987, Nowak 1999, Thomas and Gray 2001).

Rangifer tarandus is classified into 6 currently recognized subspecies in North America. The classification is based on their ecology and behavior.

- *R.t. caribou* (Gmelin 1788) is the primary resident subspecies in Saskatchewan. This sedentary subspecies is commonly referred to as woodland caribou. The subspecies has been further categorized into the "boreal ecotype", which inhabits boreal forest year round, and "mountain ecotype", which occur in the forested foothills and migrate into alpine habitat of the Rocky Mountains (Dzus 2001).
- *R.t. groenlandicus* (Linnaeus 1767) are a barren ground subspecies occurring in the Northwest Territories and Nunavut in large migratory herds. Two of these herds (Beverly and Kaminuriak) range into extreme northern portions of Saskatchewan (Arsenault 2003, Parker 1972, Thomas 1969).
- *R.t. dawsoni* (Seton 1900) is an extinct subspecies, which were found on Graham Island of the Queen Charlotte Islands, British Columbia, prior to 1935 (Banfield 1987, Thomas and Gray 2001).
- *R.t. granti* (J.A. Allen 1902) occur in Northern Yukon Territory.
- *R.t. pearyi* (J.A. Allen 1902), commonly called Peary Caribou, occur on the Queen Elizabeth Islands and on northwest Greenland.
- *R.t. tarandus* (Linnaeus 1758) commonly called the European Reindeer were introduced into the Mackenzie Delta area in 1935 (Banfield 1987).

Recent work using mitochondrial DNA does not support the current taxonomic delineation into subspecies, and future taxonomic revision is likely (Thomas and Gray 2001, Godwin and Thorpe 2000). However, this report will focus on the boreal ecotype of *R.t.caribou* (as defined by current taxonomy) residing in the Boreal Plain and Boreal Shield ecozones (Acton et al. 1998) of Saskatchewan.

2.2 Physical Description

Rangifer tarandus is a medium-sized cervid and is considered to be one of the more primitive members of Cervidae because of several features. These include: presence of annually shed antlers in both sexes; relative prominence and low placement of the 2nd and 4th digits (dew claws) which also bare some of the body weight; long metapodial bones associated with the dew claws; prominent tarsal and interdigital glands, and relatively simple crests on premolar and molar teeth (Banfield 1987).

Anatomical adaptations to cold include: a large blunt well-furred muzzle; valvular nostrils; short, broad, heavily furred ears; short well furred tail; and a compact body covered by long thick pelage (Banfield 1987). Caribou have large, crescentric hooves, which are soft-centered for gripping on ice,

and spread readily to facilitate travel in snowy and boggy terrain (Banfield 1987, Kelsall 1968, Trottier 1988a).

Rangifer is the only genus in Cervidae in which both sexes are antlered (Nowak 1999). Antler configuration is extremely variable and range in size from short spikes in calves, to majestic back-sweeping beams with semi-palmate terminal branches, flattened brow tines projecting vertically over the snout, and lateral arcing bez (second) tines in adult bulls (Banfield 1987, Trottier 1988a, Whitaker 1996). Generally only one brow tine is dominant (Banfield 1987). Antlers on cows are relatively small and spindly and are occasionally absent on females, particularly for those younger than 4 yrs (Bergerud 1976, Trottier 1988a). Annual growth of antlers is approximately six months out of phase between the sexes (Banfield 1987), but there is considerable overlap in chronology of antler shedding (Fuller and Keith 1980). Antlers are generally cast from late November/December (mature bulls), to March (young adults), to late May (bred cows) (Godwin and Thorpe 2000). Antler growth among 3 – 8 yr old bulls begins in March, and for breeding age (3+ yr old) cows in July (Fuller and Keith 1980).

Woodland caribou are larger than their barren-ground counterparts (Banfield 1987). Males are generally 25% heavier than females. Adult bulls range in weight from 160 to 250 kg and adult cows from 91 to 159 kg (Thomas and Gray 2001). Adult shoulder height, ranges from 87 to 140 cm. Adult pelage consists of a dark-brown face, back and sides, and white neck, chest, rump, and under parts (Trottier 1988a). The air-filled hollow hairs of its coat, gives caribou great buoyancy for swimming. They have a wide stance and swinging gait. Maximum running speed is 60 – 80 km/hr. Eyesight is poor, hearing is adequate, and caribou depend largely on their sense of smell to detect food and danger (Nowak 1999). Scent glands are located around the eyes, on the lower legs, feet and underside of the tail. When alarmed, caribou trot in a semi-circle with tail erect, and release an alarm scent to warn other caribou of danger (Lewin and Stelfox 1966).

Caribou fawns are brown and unspotted, but occasional dappling may be noted (Banfield 1987), weighing about 4.5 – 6.6 kg at birth. They grow rapidly over the first 5 months. Both sexes reach full maturity at 4 – 5 years.

The dental formula is $I^0/_3\ C^1/_1\ P^3/_3\ M^3/_3$ (x 2 sides) = 34. Dentition is weak, characterized by small, flexible incisors, seated in their alveoli (Banfield 1987). Inner incisors become notched with age, due to feeding habits. Upper canines are present in both sexes, but are vestigial and do not pierce the gum (Banfield 1987).

2.3 Distribution

2.3.1 North America

Woodland caribou range in North America is described by Thomas and Gray (2001), and Banfield (1987). Thomas and Gray (2001) categorized the North American range as:

1. Northern Mountain Population - occupies southern Yukon and northern British Columbia.
2. Southern Mountain Population - inhabit the Rocky Mountains of British Columbia, Alberta, and portions of Idaho and Washington.
3. Boreal Population - range from the Mackenzie Valley through boreal forest in Alberta and Saskatchewan, Manitoba, Ontario, Quebec, and Labrador.
4. Newfoundland Population - reside on the main island and some offshore islands.
5. Atlantic Population - isolated to the Gaspesie Conservation Park.

2.3.2 Saskatchewan

Saskatchewan woodland caribou represent a portion of the "boreal caribou" population described by Thomas and Gray (2001). A comprehensive representation of historic (1950 – present) woodland caribou range occupancy was compiled using caribou tracks and sightings data from wildlife aerial surveys, caribou telemetry studies, incidental sightings, and local knowledge (Figure 1). Boreal caribou are broadly distributed in preferred habitats encompassed by the Boreal Plain and Boreal Shield ecozones of Saskatchewan (Figure 1). Abundance and persistence of caribou within these ecozones is largely a function of human activities and influences on these ecozones, as well as juxtaposition of preferred habitats within those ecozones. Local populations (bands) within each meta-population tend to be relatively discrete with strong fidelity of individuals to their home ranges (Brown et al. 1986, Brown et al. 2000, Dzus 2001, Rettie and Messier 1998, Seip 1992, Stuart-Smith et al. 1997).

About 72% of the Boreal Plain ecozone (Figure 1) is forested (primarily mixed-wood and coniferous forest associations) and 16% is cultivated (Acton et al. 1998). Approximately half of this ecozone is productive commercial forest, with the forest products industry focusing on extraction of large volumes of wood fiber (aspen, jack pine, white spruce and black spruce) for pulp, paper, fence posts and railway ties. The rate of wood fiber extraction has significantly increased in recent years, following an announcement (April 1999) by the Saskatchewan government to double the size of the forest industry. Some of the most productive agricultural lands occur in the southern portion of this ecozone, where climate and soils are suited to the production of cereal grains, oilseeds, pulse, and forage crops, in addition to livestock production (Acton et al. 1998). Mining development is limited mainly to peat, silica and gravel quarrying. Oil and gas exploration and extraction occurs primarily in the southwest portion of the ecozone, and represents about 6% of the provincial oil reserves and 1% of the provincial natural gas reserves. Utility (hydroelectric and telephone) development and road development have added to the fragmentation and accessibility of this ecozone. About 8% of this ecozone is protected by national and provincial parks, and Wildlife Habitat Protection Act lands (Acton et al. 1998).

Within the Boreal Shield ecozone (Figure 1), mining (gold, uranium, copper, zinc, other heavy metals) and limited forestry are the predominant industries affecting habitat. Forest products industry expansion into this ecozone is inevitable, which raises concerns due to the paucity of basic forest and habitat inventory, site classification systems, and lack of knowledge of ecological structure, processes, functions and responses to forest harvesting and silviculture (WHC 2001). About 3% of this ecozone is protected by provincial parks or protected areas. Black spruce is the predominant tree species.

Woodland caribou distribution and populations have declined throughout their North American range since the 1900s, particularly along the southern extent of their range where most habitat encroachment and fragmentation has occurred (Cumming and Beange 1993, Edmunds 1986, MacDonald 2001, Rettie and Messier 1998). Historically, woodland caribou were probably discontinuously distributed in the boreal plain ecozone because of their need to spatially isolate themselves from other ungulate species, and their preferential selection of treed peatland complexes. Changes in range occupancy were determined by comparing all available sightings and track data (1950 – present) to recent (most recent 15 yrs). This illustrates general range contraction along the southern edge of caribou range in Saskatchewan as a result of habitat loss, fragmentation and habitat changes resulting in creation of early seral forest stages (Figure 1). The northward contraction of boreal caribou range in Saskatchewan is consistent with that reported elsewhere in North America (Bergerud 1974, Cumming and Beange 1993, Racey and Armstrong 2000, Rock 1992, Thomas and Gray 2001).

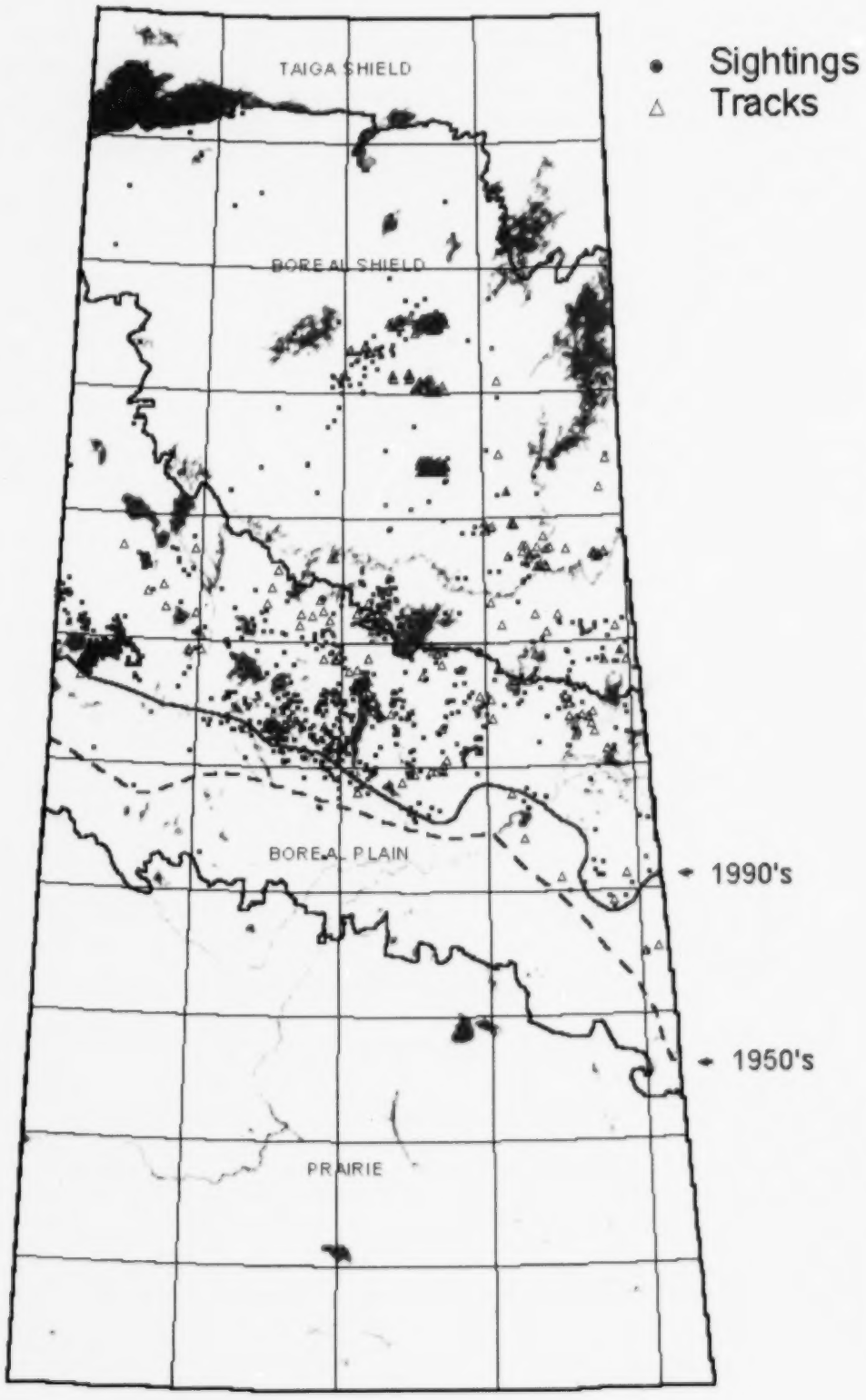

Figure 1. Woodland caribou range contraction in Saskatchewan, 1950 to present.

3.0 Habitat Selection

Assessing habitat use in relation to availability determines habitat selection (Bradshaw et al. 1995). Habitat selection occurs at several levels, is variable, and reflects the strategies used by an animal to meet habitat requirements through selection of different environmental features at each level of spatial and temporal scale to optimize biological fitness (Bradshaw et al. 1995, Holling 1992, Johnson 1980, Orians and Wittenberger 1991). Habitat selection patterns may also vary among populations studied at the same scale (Anderson 1999). At a particular scale, differential habitat selection among populations may be due to a particular population's response to influences such as forage availability, predation, disturbance, etc. in their home range (Anderson 1999, Orians and Wittenberger 1991). Habitat selection decisions made at coarser spatial and temporal scales should reveal features more important to biological fitness than decisions made at finer scales (Rettie and Messier 2000a). Habitat selection is probably related more to predator avoidance year round and to thermal cover/insect harassment factors during summer, than to food requisites (Rock 1992). Even in a completely suitable region, not all habitat is occupied, because some time elapses before a territory vacated by the death of an individual is re-colonized by a dispersing juvenile (Lande 2002).

At the landscape level, boreal caribou habitat can be viewed as a mosaic of preferred habitat patches, interspersed with other habitat patches that function primarily for dispersal and predator avoidance (Akcakaya 2001).

3.1 Woodland Caribou Management Units (WCMU)

Tracks and sightings data were compiled for Saskatchewan from a variety of sources including telemetry studies, aerial surveys, incidental sightings, and local knowledge. These data span a period of time from 1950 to present. Assessing the distribution of clusters of these data points in relation to landscape areas defined by Acton et al. (1998) and peatland complexes (see next section) allowed delineation of several caribou meta-population ranges based on an ecological framework (Figure 2). The meta-population ranges can be used as Woodland Caribou Management Units (WCMU) to provide a framework, which functions as a basis to assess the status and threats to each meta-population, as well as for recovery and conservation planning using management-by-objective (MBO) and adaptive management (AM) approaches. Management is most effective in meeting goals and objectives when they are established for population units and data are collected so that inference to population units is possible (Strickland 2001). Meta-populations are generally composed of several local populations, and occur naturally through spatial heterogeneity of ecosystems, and through habitat loss and fragmentation.

3.2 Critical Habitat

Critical habitat can be generally defined as a perpetual supply of large, contiguous areas of suitable summer and winter habitat allowing viable population(s) to disperse at low densities (0.03-0.05 caribou/km^2) to avoid predators, includes calving habitat, and has no or very limited human access or disturbance. It would also include matrix (transitional) forest habitats linking peatlands and peatland complexes, as well as recovery habitat (potential future habitat) areas.

Figure 2 identifies peatland complexes used by woodland caribou that are likely to comprise the important core use areas in relation to WCMUs, and which likely represent critical habitat for caribou. In addition, known calving areas also represent critical habitat. Any corridors linking these critical habitat patches would also be included as critical habitat. The following sections provide additional detail in defining critical habitat.

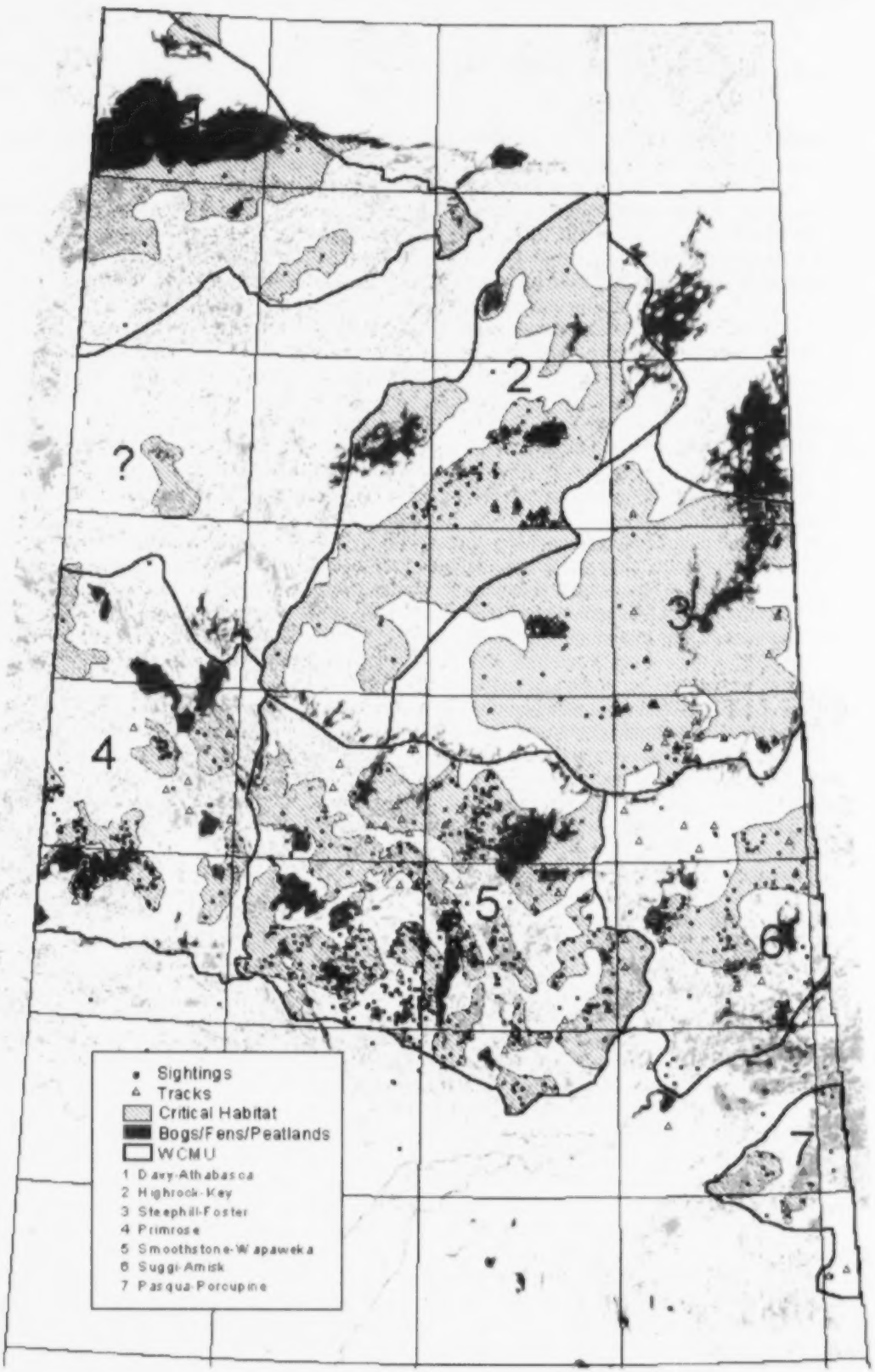

Figure 2. Critical habitat in relation to Woodland Caribou Management Units (WCMUs).

3.2.1 Species at Risk Act (SARA)

The *Species at Risk Act* (SARA, Bill C-5) was passed by the Canadian federal House of Commons on 11 June 2002. SARA requires the identification and protection of "critical habitat" in the recovery strategies and action plans of any species classed as threatened, endangered, or extirpated by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Under SARA, critical habitat is defined as the habitat that is necessary for the survival or recovery of a COSEWIC-listed wildlife species. SARA requires that the critical habitat be identified during the recovery planning process as a key element of recovery strategies and action plans. If critical habitat is not known, a schedule of studies to identify critical habitat within an action plan is required. The residence of an individual of a listed species may occur anywhere within the range of that species, but critical habitat is limited to those portions of the range that are necessary for survival or recovery.

3.2.2 Habitat Preferences

Researchers generally agree that woodland caribou are an old-growth forest species (Kelsall 1984). They are dependent on large tracts of mature boreal forest, interspersed with peatland complexes, as habitat for most of their seasonal range use and movements. Mature and over-mature conifer/lichen stands provide critical areas of winter habitat for caribou (Godwin 1990). The role of mature forests as a barrier to the influx of other cervids and their associated predators into caribou range is as important as overall habitat availability (Bergrud 1974, Bergrud and Mercier 1989, Cringan 1957, Rebizant et al. 2000, Rominger et al. 1996). Boreal woodland caribou are not restricted to landscapes dominated by treed fens and treed bogs, although most studies indicate that treed peatland complexes dominated by black spruce *(Picea mariana)* and larch *(Larix laricina)* are preferentially selected and used year-round (Anderson 1999, Bradshaw et al. 1995, Fuller and Keith 1981, Rettie 1998, Rettie and Messier 2000a, Stuart-Smith et al. 1997) as are winter habitats with moderate to high jack pine *(Pinus banksiana)* or jack pine/black spruce cover, and climax coniferous forest with ground lichens. Dense forest cover may functionally replace the role of "herd" as a concealment strategy, when comparing woodland caribou to their barren-ground counterparts (Shoesmith and Storey (1977).

Lichens are an important food source and influences habitat use and distribution (Dzus 2001). Lichens occur infrequently in forests younger than 30 years old (Scotter 1964). It may take 80 – 150 years for a boreal forest community to grow adequate amounts of lichens for caribou (Dzus 2001, Paquet 1997). This is because lichens grow extremely slowly and have limited dispersal mechanisms (Dzus 2001, Scotter 1964). Arboreal lichen abundance and productivity depends on tree age, density, species, and moisture conditions (Scotter 1964). Mesic sites are more productive that upland sites, older pine and/or spruce habitats produce more lichen that younger stands, and lichen productivity is inversely related to tree density (Scotter 1964). Conifer stands between 40 – 100 yrs old seem to provide optimal lichen supply when canopy closure is <70% (Schaefer and Pruit 1991). In Saskatchewan, woodland caribou are often attracted to dead and dying tamarack, which have an abundance of arboreal lichen (Tim Trottier, personal comm.). Woodland caribou tend to avoid shrub-rich habitats, disturbed/fragmented areas, marshes, heavily forested wetlands and uplands.

A telemetry study of woodland caribou occupying the Boreal Plain ecozone of central Saskatchewan reported preferred habitat types to be open peatland, treed peatland, lowland black spruce, and upland black spruce/jack pine (Rettie 1998). Further analysis indicated a coarse scale (seasonal range) preference of peatlands and black spruce dominated stands relative to recently disturbed stands and early seral stage forests (Rettie and Messier 2000a). Rettie and Messier (2000a) reported a fine scale (daily area used) preference for peatlands and black spruce forests to all other habitat types. A sightings and track study on the Boreal Plain and Boreal Shield ecozones of east-central Saskatchewan revealed most sightings compiled from a 27 year period occurred in lowland habitat (treed and open muskeg) types (72%) and mature coniferous (jack pine/black spruce ridges,

25%) forest (Trottier 1988b). Woodland caribou may also seek out open windy areas during summer to reduce harassment by biting insects (Trottier 1988b).

Telemetry studies conducted in the boreal plain of northeastern Alberta characterized woodland caribou preference for forest-open fen complexes with >50% peatland coverage (ie. peatland complexes with >25% forest and >25% open areas, and forested fens with any combination of tamarack, black spruce, willow and birch), and forested bogs with 85-100% peatland coverage (raised bogs, and peatlands dominated by black spruce) (Bradshaw et al. 1995). Patterned and non-patterned open fens and forest/open fens with <50% peatland coverage were used randomly (Bradshaw et al. 1995). Upland areas and non-patterned fens with <50% peatland coverage were avoided (Bradshaw et al. 1995). Woodland caribou occupying the boreal plain ecogregion of northern Alberta were not restricted to landscapes dominated by treed peatlands and made use of upland-dominated habitat at the coarse (ie. landscape level) scale (Anderson 1999). At a finer (ie. stand level) scale, Anderson (1999) reported that caribou selected treed peatland stands over all other habitat classes. Stuart-Smith et al. (1997) reported caribou telemetry locations in northeastern Alberta were restricted to peatland complexes, and that home ranges were correlated to the size of the peatland complexes. James (1999) reported boreal caribou selection for bog/fen complexes over adjacent well-drained habitats during all seasons. Fuller and Keith (1981) reported most caribou telemetry locations were in lowland cover, predominantly black spruce bogs.

Studies in Manitoba indicate preferential use of peatland complexes (Brown et al 2000) and general avoidance of harvested areas and poplar-dominated sites (Brown et al. 1998). Darby and Pruit (1984) reported primary range occupancy by caribou in southeast Manitoba to consist of mature coniferous forest uplands dissected by semi-open and open bogs. Hillis et al. (1998) concluded that woodland caribou in northwest Ontario select habitats containing moderate to high conifer cover and avoided disturbed areas and shrub-rich habitats.

Woodland caribou populations are very sensitive in landscapes with a combination of smaller fen/bog patches and higher proportion of upland, because of lower calf survival and smaller home ranges. The minimum peatland patch size or habitat configuration that will support a woodland caribou population is not known. However, at the stand level (fine scale), treed peatlands are an important habitat component regardless of landscape level (coarse scale) habitat configuration. A multi-scale assessment of habitat use and selection should be used to understand woodland caribou ecology in a given area. This would be a useful approach in defining critical habitat, as well as improve range-specific management in a management-by-objective framework.

3.2.3 Calving Habitat

Habitat use and selection alone should not be used to define critical habitat. Woodland caribou usually demonstrate calving-site fidelity (Brown et al. 1986, Brown et al. 2000, Kelsall 1984, Shoesmith and Storey 1977, Trottier 1988a). Bergerud and Ballard (1988) considered critical habitat for caribou in south central Alaska to be their calving range, where they interact with predators and have calves that are extremely vulnerable to predation. Female woodland caribou selected both black spruce dominated stands and peatlands throughout the year, and for calving and post-calving (Rettie and Messier 2000a). Boreal caribou attempt to reduce calf predation by using islands and shorelines as escape habitat for calving (Bergerud 1985, Cumming and Beange 1987, Bergerud et al. 1990); or low predator density forest wetland habitats (Brown et al. 1986); or disperse over the landscape in areas where distinct habitat refuges are not available (Bergerud 1992, Brown et al. 1986, Dyer 1999).

3.3 Forage/Nutrition

Caribou are primarily ruminant grazers, which select a wide variety of softer, more nutritious and digestible parts of herbaceous forage over woody browse (Edwards and Ritcey 1960). Sedges, grasses, forbs, lichens, fungi, and the leafy foliage of willow and other shrubs constitute summer foods (Bergerud 1974). They have specialized bacteria and protozoa in their rumens to efficiently digest lichens (Thomas and Gray 2001). Arboreal and fruiticose ground lichens, which primarily occur in mature forest habitat, comprise a large proportion of the annual diet of woodland caribou (Thomas et al. 1996, Trottier 1988a), and are highly digestible provided sufficient nitrogen is available in the rumen (Thomas and Kroeger 1981, Thomas et al. 1984).

Lichens are more important locally to caribou populations dependent on them during winter (Nieminen and Heiskari 1989, Servheen and Lyon 1989). Winter diet can be comprised of 60-70% lichens. Anderson (1999) reported highest habitat selection at the third order selection scale (ie. within an animal's home range) was for treed bogs with high abundance of *Cladina* spp. (reindeer lichen). Caribou are not limited by lichen supply (Bergerud et al. 1984b, Seip 1991), provided there are sufficient foraging areas available to allow herds to cope with stochastic events such as severe snow conditions, wildfire and timber harvesting (Schaefer and Pruitt 1991). By utilizing lichens as a food source not normally sought by other ungulates, boreal caribou can spatially separate themselves from other species to reduce predation risk (Dzus 2001). Arboreal lichens may represent a large proportion of winter forage when snow depth and snow crusting impairs access to terrestrial lichens, as observed in mountainous environments (Cumming and Beange 1987, Edmonds and Bloomfield 1984, Fuller and Keith 1981, Serveen and Lyon 1989).

Caribou usually select against mosses, senescent or waxy leaves of shrubs and herbs, and aromatic evergreens (Thomas and Kroeger 1981, Thomas et al. 1984).

Ruminant foraging behaviour is characterized by regular alternation between periods of activity and rest. In winter, caribou typically forage for 2-3 hours, followed by a 2-3 hour period to rest and ruminate at mid-day, followed by a second foraging event in the afternoon. Foraging takes from 35-50% of a reindeer's time, more in winter than in summer (Bradshaw et al. 1997, Hillis et al 1998). Having insufficient time available to forage, could prevent a wild ruminant from meeting it's daily energy requirements (Renecker and Hudson 1993). If a ruminant responds to disturbance during a feeding event, the feeding event was likely interrupted. This is particularly important in winter, when caribou are nutritionally stressed and unable to compensate for increased energy costs associated with disturbance (Bradshaw et al. 1997, Dyer 1999). This nutritional stress may be cumulative if subjected to repeated disturbance.

Caribou may loose 10 – 26% of their autumn weight during winter depending on winter severity or level of disturbance (Dyer 1999), and is usually about 15% (Bradshaw et al. 1998). Caribou can reduce their metabolic rate by as much as 30% during winter to conserve energy (Dyer 1999, McEwan 1968, McEwan and Whitehead 1970). Males eat little during the rut and may lose up to 25% of their body mass (Dzus 2001). Adamczewski et al. (1987) reported gestational costs representing 12-14% of energetic maintenance costs by late winter for pregnant caribou. Disturbance results in energetic costs that are additive to the energy budget of caribou.

Excessive winter weight loss by pregnant caribou can cause embryo resorption or premature birth in rare situations (Cameron et al. 1993). Undernourishment may also delay parturition, resulting in reduced opportunity for calves to maximize growth before winter (Bergerud 1975, Cameron et al. 1993, Skogland 1983). Under-nutrition of calves and cows can increase the likelihood of calf mortality due to predation (Adams 2003, Bergerud 1975, Cameron et al. 1993, Couturier et al. 1990, Dauphine and McClure 1974, Whitten et al. 1992), and can also reduce birth mass of calves (Adamczewski et al. 1987, Adams 2003, Bergerud 1975, Rognmo et al. 1983, Skogland 1984). Small calves experience higher mortality than larger ones (Rognmo et al. 1983).

3.4 Snow

Caribou feed on ground lichens when snow cover is <50-100 cm in depth, and use arboreal lichens when availability of terrestrial lichens is low (Kelsall 1984, Thomas and Gray 2001), or where snow depth precludes cratering for forage (Rominger and Oldemeyer 1990, Rominger et al. 1996). Caughley and Gunn (1993) suggest that depth and hardness of snow above forage is usually the limiting factor, not the absolute forage supply. Stuart-Smith et al. (1997) reported a significant negative relationship between snow depth and movement rates. The energetic costs of locomotion increase exponentially for caribou walking in un-crusted snow with increased snow depth (Dyer 1999, Fancy and White 1987). Caribou will use denser timber stands during periods of high snow accumulation, particularly in late winter when the snow surface is crusted (Bradshaw et al. 1995, Darby and Pruitt 1984, Fuller and Keith 1981). Snow depths of $\geq$ 100 cm impedes caribou movement (Bradshaw et al. 1997). As snow depth approached 75 cm and 400gm/cm^2 hardness, caribou in Manitoba switched from treed bogs to jack pine ridges (Kelsall 1984, Stardom 1975).

High snow accumulation can induce considerable loss of body mass through lowered foraging opportunities and/or large energetic costs associated with impeded movement (Bradshaw et al 1997, Fancy and White 1987, Swift et al. 1980). During winters of high snow accumulation and surface crusting, the energetic costs of displacement due to disturbance may triple (Fancy and White 1987). The effects on physical condition can persist into subsequent years, even if those subsequent years are relatively mild. Therefore, human-related disturbance in caribou habitat should be restricted during harsh winters (Bradshaw et al. 1987).

If food does become a limiting factor, it would be during late winter, in years where unfavorable snow conditions force caribou onto upland sites (Rock 1992).

3.5 Weather

During cold periods, and with increasing snow cover, caribou make more use of shelter provided by dense coniferous stands (Trottier 1988a, Stardom 1975). There is no direct evidence that inclement weather causing hypothermia of newborn calves is a major source of mortality (Bergerud 1996). Adverse weather can suspend reproduction and can result in nutritional related mortality of calves and adult caribou (Thomas and Gray 2001).

Warming associated with global climate change may have several consequences on caribou population dynamics including alteration of habitat through increased wildfire frequency and severity, changes to forage type, quality and abundance, altered snow conditions, changes in predator/prey dynamics, and increased forest resource use and extraction (Dzus 2001).

3.6 Water

Treed fen areas may be too wet during summer to allow easy movement by caribou, but in late fall when the ground has begun to freeze and plants still have their nutritional value, caribou may shift to these areas (Anderson 1999). Proximity to water provides cows and calves an avenue of escape from predators (Godwin 1990).

3.7 Cover

Drier treed bog sites may provide better habitat for bedding during summer, but during winter, fens may provide similar bedding habitat to treed bogs (Anderson 1999).

3.8 Habitat Fragmentation

Characteristic features of highly fragmented landscapes are that individual habitat patches are so small that small local populations have a high risk of extinction, and, suitable habitat covers a small fraction of the total landscape (Hanski 2002). Boreal caribou require large continuous wilderness areas composed of the various habitats needed among seasons and during the various segments of their lifecycle. Wildfires and habitat alteration by resource extraction industries (eg. agriculture, forestry, peat mining, oil and gas) in caribou range have the cumulative effect of fragmenting large areas of old growth forest. This has the effect of increasing populations of other cervid species and subsequent increase of wolf-related mortality. The increase of other cervid populations could also have the potential effect of introducing a disease or parasite that under natural circumstances may not have had an opportunity to get there. Habitat fragmentation also fragments populations, which can cause local extinctions (Fahrig and Merriam 1985, Fahrig and Merriam 1994, Lande 1988, Sauders et al. 1991).

Little is known about the influence of natural disturbance has on boreal caribou. However, since industrial disturbance is cumulative with natural disturbances such as wildfire, it is very important to consider the cumulative effect of both within a planned landscape (Bradshaw et al. 1998). Stuart-Smith et al. (1997) suggested that caribou tend to avoid matrix habitat, which consists of diverse habitat types and boundaries between habitat types. Smith et al. (2000) reported long term avoidance of a specific type of matrix habitat consisting of forest habitat subjected to standard 2-pass logging, which resulted in highly fragmented landscape after the first pass. Timber harvesting may result in a more widespread increase in moose and white-tailed deer than wildfires because of the dispersed nature of a 2-pass timber harvest design (James 1999). Any process that fragments the landscape, restricts the movement of caribou, and makes them more predictable in time and space, can potentially increase mortality (Seip 1991). Commercial logging may not mimic the effects of wildfire in creating optimal conditions for the renewal of lichen growth (Dzus 2001). However, establishment of new lichen colonies on disturbed areas can result from dispersal of wind blown lichen fragments created by logging operations (Harris 1996).

3.8.1 Wildfire

Forest fire frequency is variable across woodland caribou range. Wildfires occurring in the Boreal Plain Ecozone tend to be smaller and less variable in size, within year, compared to those occurring on the Boreal Shield Ecozone (Table 1). This is probably partly due to the efforts of fire suppression, but may also be related to landscape differences between the boreal plain and boreal shield. In both ecozones, fire size is also variable among years, primarily in relation to moisture levels (ie. drought year vs wet year).

Wildfire has always been a dominant force shaping boreal ecosystems. Plant succession following a wildfire is dependant on site potential, size of burnt area, fire intensity, effects on soil properties, climatic conditions for several year post-burn, seral stage of vegetation at the time of the burn, and seed availability for dispersal (Scotter 1964). Lichens may be completely consumed by intense fire, but will re-invade over time through windblown fragments (Harris 1996). Wildfire has detrimental short-term (<50-60 years) effects on caribou habitat, which includes the destruction of lichen forage important to winter caribou diet (Cumming 1992, Rebizant 2000). However, these burnt areas

Table 1. Comparison of wildfire size in the boreal plain and boreal shield ecozones, 1981-2000.

Fire Year	Boreal Plain Ecozone			Boreal Shield Ecozone		
	$\bar{x}$ Fire Size (ha)	±S.D.	n	$\bar{x}$ Fire Size (ha)	±S.D.	n
2000	21.6	154	221	768.3	4,725	177
1999	144.4	1,533	411	380.7	2,592	319
1998	379.7	5,822	643	1,187.6	7,340	614
1997	6.0	30	279	10.6	47	199
1996	15.5	113	245	50.9	328	181
1995	1,716.8	10,907	319	3,461.6	19,036	318
1994	15.8	109	306	2,219.0	12,348	379
1993	908.5	15,633	373	1,023.1	5,694	263
1992	65.9	750	410	263.8	2,720	271
1991	81.6	1,230	485	599.2	3,269	265
1990	15.0	140	468	387.2	2,655	427
1989	130.5	1,202	492	953.4	4,776	505
1988	66.8	1,308	663	90.9	713	362
1987	164.9	3,259	460	327.6	1,986	504
1986	18.0	182	287	39.3	275	202
1985	19.4	218	283	421.4	2,306	228
1984	30.9	292	427	695.1	4,678	423
1983	21.7	145	166	186.9	995	266
1982	15.8	89	310	216.4	1,149	278
1981	11.1	47	367	3,937.9	22,516	598
Years pooled	196.9	4,589	7,615	1,054.2	9,130	6,779

produce large amounts of lichen in the long-term (Euler et al. 1976, Klein 1982), and may be required in the long-term (>50-60 years) to alter landscape vegetation characteristics, allowing lichen biomass to be maintained or increased (Dzus 2001, Rebizant 2000, Schaefer and Pruitt 1991). Wildfire can also create barriers to movement through windfall, alteration of snow cover characteristics, and associated loss of forage (Davis and Franzmann 1979, Kelsall et al 1977, Klein 1982, Schaefer and Pruitt 1991).

Woodland caribou habitat in the Boreal Plain Ecozone of central Saskatchewan is generally associated with low, wet areas, which seldom burn (Trottier 1988a). On the Boreal Shield Ecozone, caribou habitat is generally interspersed with rock outcrops and sandy plateaus which experience moderate to high fire frequencies (Trottier 1988a). High fire frequency areas are not preferred caribou habitat, but where major burns occur in caribou habitat, the green areas (muskegs, lakeshores, riparian habitat, ravines) which persist, are potentially attractive to caribou (Trottier 1988a).

3.8.2 Human Activity and Development

The effects of disturbance for woodland caribou are difficult to assess because range shifts tend to occur over decades (Geist 1978). In most impacted landscapes, the number, location, and size of habitat patches, as well as the demographic parameters of the populations inhabiting them, change through time (Akcakaya 2001). Large-scale anthropogenic disturbances that affect habitat patch dynamics have direct and indirect consequences for caribou.

Industrial activities that alter caribou habitat and increase access for humans and predators in caribou range will contribute to decline of caribou populations (Brown et al. 2000, Rock 1988). The effects of human activity and development on woodland caribou and caribou habitat have several

consequences. These include functional habitat loss due to displacement and avoidance (Dyer 1999, Dyer et al. 2001, Klein 1971, Nelleman and Cameron 1998, Smith et al. 2000), direct habitat loss due to physical alteration of caribou habitat, changes in predator-prey relationships (Edmonds and Bloomfield 1984), energetic costs associated with disturbance and displacement (Bradshaw et al. 1998, Murphy and Curatolo 1987), disruption of rutting and calving (Bradshaw et al. 1997, Bradshaw et al. 1998, Dyer et al 2001), and barrier effects (Curatolo and Murphy 1986). The most hazardous and long-term effects of disturbance are avoidance or abandonment and subsequent reduction of a population's range (Geist 1978, Klein 1971) associated with permanent modification of the habitat mosaic caribou use. For example, if a regenerating forest is harvested or burned before it reaches an age at which it can sustain lichen (and caribou), then habitat alteration becomes habitat loss (Dzus 2001).

Linear corridors (seismic lines, hydro-electric corridors, communication corridors, trails, roads, highways, etc.) in, around and through woodland caribou habitat have proliferated as a consequence of resource extraction (logging, mining, oil and gas development, agriculture (cereal and forage crops in the south, wild rice in the north, and commercial blueberry farms in eastern Canada), recreational fishing and hunting, recreational snowmobiling, commercial outfitting (fish and wildlife), and commercial trapping). Linear developments can impact caribou in several ways, depending on the nature of the development and level of associated disturbances. Corridors provide access to humans and predators to penetrate vast tracts of habitat that was not formerly accessible (Dzus 2001, Rock 1992), and may significantly increase encounter rates between predators and caribou (James and Stuart-Smith 2000). Roads can result in increased caribou mortality due to improved access by predators (including humans) using roads (Thurber et al. 1994), trails (Edmonds and Bloomfield 1984), seismic lines (Dyer 1999), power lines, and pipeline right-of-ways as travel corridors (Bergerud et al.1984b, Harrington 1996, James 1999, James and Stuart-Smith 2000, Seip and Cichowski 1996, Thurber et al. 1994). James (1999) found that wolves traveling on linear corridors moved 2.8 times faster (1.4 km/hr) than average speed of travel in forest (0.5 km/hr). Caribou are likely to habituate slowly and incompletely to vehicular traffic since vehicles represent potential predators, and are highly unpredictable in time and space (Cronin et al. 1994, Dyer 1999). Roads can cause caribou mortality through caribou/vehicle collisions (Dyer 1999, Dzus 2001, Johnson 1985), particularly during winter, where they are attracted to highways treated with road salt. Roads and pipelines may also function as barriers to caribou movement (Curatolo and Murphy 1986, Dyer 1999). There have been no studies to date investigating the effects of various levels of vehicle traffic on caribou, although results from Dyer (1999) indicate lightly used roads can function as barriers to woodland caribou movements. Proliferation of corridors combined with the inherent natural curiosity of caribou, could compromise the survival strategies of caribou (Dzus 2001, Edmonds 1986).

Functional habitat loss occurs when caribou are disturbed and displaced from an otherwise suitable area (Anderson 1999, Dyer 1999, Dyer et al 2001, Nelleman and Cameron 1998). Dyer (1999) documented the displacement of caribou by up to 1000 m resulting in 48% reduced use of habitat by caribou occupying his study area as a consequence of avoidance of roads, seismic lines and recently developed oil well sites. The level of avoidance was dependant on the level of human activity (Dyer et al. 2001). Smith et al. (2000) reported boreal caribou avoidance of areas recently fragmented by timber harvesting in Alberta by an average distance of 1200 m. The effects of cumulative disturbance due to industrial activity can result in disruption of rutting and/or calf production and survival (Bradshaw et al. 1997, Bradshaw et al. 1998). Cow/calf pairs respond to lower levels of disturbance than bulls and calfless cows (Bergerud et al. 1984b, Murphy and Curatolo 1987). Functional habitat loss from industrial development can be considerably greater than the area disturbed (James 1999).

Direct habitat loss occurs as a result of drastic physical alteration of habitat by timber harvesting of upland areas adjacent to lowland peat complexes, and construction of roads and other industrial infrastructure (Anderson 1999, Dyer 1999, Smith et al. 2000, MacDonald 2001). Preferred habitats may not be at risk from commercial logging, but caribou may still be put at risk from indirect effects of timber harvesting in upland areas adjacent to peatland complexes. Effects may include barriers to movement (Bergerud et al. 1984b, Dyer 1999, Johnson and Todd 1977, Miller et al. 1971), and loss of habitat integrity (James 1999). Barrier effects associated with roads could be more severe at the edges of peatland complexes, where the combination of sub-optimal habitat and man-made barriers

could arrest caribou dispersal (Dyer 1999). Fen/bog complexes likely provide a caribou refuge, but the refuge effectiveness may be eroded by development of linear corridors in and proximate to the bog/fen complexes (James 1999). Timber harvesting has the effect of reducing herd distribution, winter range size and daily movement patterns by fragmenting habitat and concentrating caribou into unlogged portions of their winter range (Smith et al. 2000). This induced behavioral response is at odds with their adaptive strategy of dispersing at low density within large range areas (Dzus 2001). Long-term caribou conservation would require a long-term habitat supply plan with allowable cut accommodations, to ensure suitable amounts and spatial distribution of caribou habitat on the landscape.

Timber harvesting close to fen/bog complexes occupied by caribou may considerably increase the **predation pressure** on caribou, which can be attributed to increased moose densities in response to regenerating browse in logged areas and corresponding increases in wolf density (James 1999, Seip 1992). Post-logging succession in boreal forest will elevate moose, white-tailed deer and elk densities, and cause a positive numeric response in wolves (Marshall 1997, Messier 1994) either in the form of wolf redistribution, or population increase, which would result in increased predation rates on caribou (Brown et al. 2000, Rettie and Messier 1998, Seip 1992). This is particularly important if increases in other ungulate species provided a sufficient prey base to allow wolves (and possibly bears) to occupy caribou range year round (Bergerud 1974, Dzus 2001).

Noise disturbance significantly increases a caribou's rate of movement away from the source, and also resulted in changes to the types of habitat patches used (Bradshaw et al. 1997). There are also energetic costs associated with disturbance as a consequence of interruption of foraging activity and movement away from the disturbance source (Bradshaw et al. 1997, Cuyler and Oritsland 1993, Skogland and Grovan 1988). These costs are particularly significant during winter.

3.9 Habitat Connectivity

Habitat by itself does not determine whether a species will persist or recover. Population persistence depends on the amount and spatial distribution of habitats across a landscape, what dynamics are occurring within the habitat that may affect the population or it's occupied habitat, and the scale at which the organisms interact with landscape pattern (Keitt et al. 1997). Habitat connectivity refers to the configuration and relative juxtaposition (structural connectivity) of habitat patches within a landscape matrix, and whether there are any barriers affecting the dispersal ability (functional connectivity) of a species within the landscape matrix. Wildfire and human activities fragment habitat. This represents significant habitat alteration, which for some species represents habitat loss and fragmentation, and subsequent isolation of populations in the remnant habitat patches.

The connectivity between the remnant habitat patches is essential to natural movement, dispersal ability, gene flow, and ultimately the future viability of populations, particularly if the population is small and/or exists at low density. Maintenance of connectivity of remnant habitat patches is necessary in a fragmented landscape to ensure ecosystem function and long-term persistence of caribou populations. At the individual level, loss of habitat connectivity can significantly reduce the ability of an individual to exploit resources (nutrition, access to mates, predator avoidance) within it's home range. At the population level, reduced habitat connectivity has significant implications to long-term population viability. Implications include a decreased ability to respond to short and long-term habitat changes, and reduced genetic variability due to increased isolation, and impaired dispersal.

Temporal habitat fragmentation by wildfire and logging produces functional caribou habitat loss, but disturbance is necessary to produce future habitat. The effect of temporal habitat loss depends on the magnitude of the disturbance, the time required for the habitat to rebound to a state suitable for caribou to reoccupy it, and the ability of displaced caribou to locate alternate suitable habitat and persist over the long-term.

4.0 Population and Community Ecology

4.1 Annual Movements

Spatial overlap between summer and winter home ranges was reported to be high, suggesting no home range seasonality (Stuart-Smith et al 1997).

Boreal woodland caribou are relatively sedentary and tend to carry out only short seasonal migrations (15 – 80 km) between seasons (Cumming and Beange 1987, Edmonds 1988, Fuller and Keith 1981), relative to the extensive movements of barren-ground caribou (Edmonds 1986). Seasonal movements vary with sex and age (Trotter 1988a). Seasonal migration may be a predator avoidance strategy, because ungulate populations that do not migrate are more susceptible to limitation by resident predators than are migrant populations (Fryxell et al. 1988). Woodland caribou in central Saskatchewan are non-migratory (Rettie and Messier 2000b) indicating substantial overlap between annual summer and winter ranges. Darby and Pruitt (1984) reported a similar finding for caribou in southeastern Manitoba. In the absence of migration behavior to avoid predation risk (Fryxell et al. 1988), Saskatchewan woodland caribou must select ranges that minimize contact with predators.

4.2 Home Range

Annual home range sizes of woodland caribou in the western Prairie Provinces have been reported by several authors (Table 2). Home range size is related to season and habitat, with home range areas smaller in summer relative to winter (Shoesmith and Storey 1977, Stuart-Smith et al 1997). Home range size is generally smaller for females relative to males during summer, but are similar in size among sexes during winter (Fuller and Keith 1981, Stuart-Smith et al. 1997). Range size increases with the onset of fall rutting activity (Edmunds and Bloomfield 1984, Shoesmith and Storey 1977, Trottier 1988a).

Table 2. Comparison of home range size across boreal caribou range.

Adult home range size (km²)							
Summer		Winter		Annual		Jurisdiction	Source
♂	♀	♂	♀	♂	♀		
26	24	784	147	607 - 1,470		West-central Alberta	Edmonds (1988)
95	24	320				Alberta Foothills	Edmonds and Bloomfield (1984)
63	77	335	137	1,196	539	Northeast Alberta	Fuller and Keith (1981)
564	537	669	650	711		Northeast Alberta	Stuart-Smith et al. (1997) [a]
---	---	---	---	208 – 1,240		Central Saskatchewan	Rettie and Messier (2000b)
107		253		---	---	Central Manitoba	Shoesmith and Storey (1977)
---	83	---	---	---	581	Central Manitoba	Brown et al. (2000)
175 - 190		95 - 140		---	---	Southeastern Manitoba	Darby and Pruitt (1984)

[a] migratory mountain ecotype with distinct summer and winter ranges

Home ranges tend to partially overlap among individuals. There tends to be considerable overlap between summer and winter ranges for individual animals (Stuart-Smith et al. 1997).

Most caribou populations are traditional and specialized in their use of particular seasonal ranges. Winter ranges are particularly sensitive because caribou depend largely on the relationship between

adequate food availability and variable snow cover (Kelsall 1984). Calving areas must provide a measure of protection from predators and insect harassment (Kelsall 1984). Traditional movement corridors between seasonal ranges probably also represents critical habitat.

4.3 Dispersal

Boreal caribou are gregarious, but tend to gather in small family size bands that are relatively sedentary, with relatively little exchange of individuals between occupied peatland complexes. Consequently, the level of isolation among caribou bands within a metapopulation is likely a function of their relative juxtaposition to other bands, the size of those bands, and the movement corridors linking them. Dispersal between local populations enables a metapopulation to persist through genetic interchange. Dispersal is most likely when environmental conditions are extremely unfavorable and during range expansion by growing populations (Thomas and Gray 2001).

The over-winter dispersion of woodland caribou is irregular and is probably an adaptive response to predation pressure (Bergerud 1985, Cumming and Beange 1987). Winter dispersion of woodland caribou into discrete aggregations has been reported elsewhere (Fuller and Keith 1981, Shoesmith and Storey 1977, Stardom 1975), but fidelity to, and extended use of, fixed wintering areas has not been reported. Dispersion into sexually segregated groups is related to season (see section 5.3.3).

4.4 Reproduction/Life History

Woodland caribou have a polygynous mating system, but unlike other cervid species, they have a very low reproduction rate, primarily because age at first breeding is relatively older than other cervid species, and because twinning is extremely rare. Theoretically woodland caribou males reach sexual maturity at 18-20 months, but generally do not breed before 3 or 4 years due to social dominance hierarchy of the herd and competition among bulls. Most females are 2+ years old before first breeding and rarely produce more than one calf/cow in a year (Bergerud 1974, Dyer 1999, Godkin 1986, McDonald and Martell 1981). Twinning is very rare (McDonald and Martell 1981, Shoesmith 1976, Trottier 1988a).

Breeding occurs from mid-September through mid-October. In hunted populations, a skewed adult sex ratio in favor of females, and a young male age structure may affect availability of males for effective reproduction during the rut by delaying conception times and resulting in delayed calving (Holand et al. 2003). Pregnancy rates are typically about 85% (Bergerud 1980a, Kuzyk et al. 1999, Stuart-Smith et al. 1997) to 94% (Rettie and Messier 1998). The gestation period spans approximately 229 days (Bergerud 1975). Calving occurs during early May through early-June. Rettie and Messier (2000b) reported a mean calving date of May 15.

4.5 Mortality

Longevity is usually 12 – 15 years, but can be as long as 17 years (Bergerud 1980a, Stuart-Smith et al. 1997). Average annual adult survival rates for woodland caribou have been reported by Bergerud (1980a) in North American range (87-93%), Brown et al. (2000) in Manitoba (90%), Edmonds (1988) in west-central Alberta (78%), Fuller and Keith (1981) in Alberta (85%), McLoughlin et al. (2003) in north-east Alberta (86-93%), Rettie and Messier (1998) in Saskatchewan (84%), Seip (1992) in British Columbia (71-92%), and Stuart-Smith et al.(1997) in Alberta (88%). Adult mortality is most common in summer (Rettie and Messier 1998). Even minor increases in adult and/or calf mortality can cause a trend of population decline.

Calf mortality is an important component of caribou population dynamics (Adams et al. 1995, Rettie and Messier 1998). Calf survival to one year is usually low (Edmunds 1988, Fuller and Keith 1981) and varies temporally (annually) and spatially (place to place). Most calf mortality occurs during the first few months of life. Typically only 30-50% of calves survive their first year of life (Thomas and Gray 2001). Depredation by natural predators can account for as much as 50% of the annual calf crop prior to 6 months of age (Bergerud 1980a). Fuller and Keith (1981) reported calf survival within the first 2 months of life was 42%. Adams et al. (1995) reported that the majority of calf mortality by bears occurred with calves <10 days old, and that wolf depredation accounted for a significant amount of calf mortality, peaking at about 10 days after onset of calving. They also reported higher neonate survival of calves born during the peak of calving (ie. born within 5-8 days of calving onset), than other calves, and that 43% of the mortality occurred within 30 days of age. Calf survival is related to a combination of calf birth weight (Boertje et al. 1996), length of previous years calf rearing and nutritional status (Adams and Dale 1998), particularly in the third trimester (Thomas and Gray 2001).

Boreal caribou minimize predation risk during calving by spacing out in the forest to calve on islands in lakes and muskegs, or along lakeshores. Prior to parturition, female caribou use predator avoidance (ie. become solitary and disperse into isolated predator-safe locations to calve) and synchronous calving as strategies to reduce potential for calf depredation (Bergerud 1985, Bergerud 1992, Bergerud and Page 1987, Bergerud et al. 1984a, Bergerud et al. 1990, Dyer 1999, Poole et al. 2000, Trottier 1988a). Therefore, critical habitat for caribou includes their calving areas, in relation to where they interact with predators, and have calves that are extremely vulnerable to predators (Bergerud et al. 1984a). Stuart-Smith et al. (1997) reported highest calf mortality was during the first month of life, and that calf survival was lower in landscape characterized by smaller peatland patches and higher proportion of upland habitat.

4.5.1 Natural Predators

Predation is an important factor limiting boreal caribou populations. Caribou populations attempt to compensate by spatially removing themselves from other ungulate prey species using a strategy of sparsely distributing themselves in very large range areas composed of habitats that contain very low densities of alternative prey (Bergerud 1992, Bergerud et al. 1984b, Seip 1992). They also space out temporally through seasonal migrations from summer to winter ranges (Edmunds 1988), through habitat selection, or by predator evasion. Pregnant cows, for example, disperse within their range and limit their movements, thereby evading predation by becoming solitary to have their calf (Bergerud 1985, Bergerud and Page 1987, Bergerud et al. 1984a, Bergerud et al. 1990, Brown et al. 1986, Brown et al. 2000, Cumming and Beange 1987). By reducing exposure to predators, females can optimize their lifetime reproductive success by increasing their chances to rear a calf from birth to recruitment age (Rettie and Messier 2000b).

Major predators influencing woodland caribou population dynamics are humans, wolves *(Canus lupus*), and bears (*Ursus* spp.)(Ballard 1994, Bergerud 1988). Other natural predators include coyote *(Canus latrans*), lynx *(Lynx canadensis*), cougar *(Felis concolor*) and wolverine *(Gula gula)*, however, their effect on population caribou dynamics is probably minimal. In studies conducted where wolves are present, they are considered to be the major source of adult mortality (Bergerud 1988, Edmonds 1986, Edmonds 1988, Seip 1992, Stuart-Smith et al. 1997), and calf mortality (Adams et al. 1995, Bergerud and Ballard 1988).

Increased natural depredation can occur in areas where old growth forest habitat is altered by fire or timber harvesting. The creation of earlier seral stages of habitat is more suitable for sustaining other cervid species at higher population densities. The larger prey base in turn stimulates a higher predator population and increased depredation rates on caribou resulting in subsequent caribou population decline (Bergerud 1974, Cumming 1992, James 1999, Paquet 1997, Pimlott 1967, Rettie and Messier 2000a, Seip 1992). Messier (1995) calculated a minimum density of 0.2 moose/km^2 is required to support a wolf population. Even with alternative prey, caribou are a preferred food item by

wolves where caribou are locally abundant (Holleman and Stephenson 1981). Small changes in predation pressure may have significant consequences on the long-term viability of local caribou populations (Dyer 1999, James 1999).

Predator presence in a large peatland complex was lower that in the surrounding upland area (James 1999), which suggests that boreal caribou may use peatland complexes to minimize predation risk in addition to using them as a foraging source of terrestrial lichens in winter (Anderson 1999).

4.5.2 Diseases and Parasites

Diseases do not appear to be a major source of mortality in woodland caribou (Bergerud 1971, Trottier 1988a). Some of the most common pathogens are listed in Table 3. Further information on these diseases can be found in SAF (1990), Trottier 1988a, and Wobeser (1990). Insect harassment can negatively affect daily activity budgets and nutrient acquisition of caribou, and ultimately body condition, survival, reproduction rate and calf recruitment (Colman et al. 2003).

Table 3. Common diseases and pathogens known to affect wild and/or domesticated caribou and reindeer.

Disease/Pathogen	Common Name	Symptoms	Diagnosed Cases in Saskatchewan
VIRAL			
Herpesvirus	Malignant Catarrhal Fever	Fatal, gastrointestinal/upper respiratory tract infection	No
Pox Virus	Contagious Ecthyma	Generally non-fatal, sore mouth, dermatitis	No
Virus	Bluetongue (Epizootic haemorrhagic disease)	Non-fatal, mild fever	No
PROTOZOAN (Bacteria)			
Besnoitia tarandi	Besnoitiosis	Dermal and organ cysts	Yes [1]
Brucella suis (biovar 4)	Brucellosis	Fatal, impacts reproductive system	No
Fusobacterium necrophorum	Necrobacillosis (foot rot)	Foot rot, abscesses	No
Leptospira spp.	Leptospirosis	Fevers, impacts reproductive system	No
Mycobacterium bovis	Tuberculosis	May be fatal, affects respiratory system	No
Mycobacterium paratuberculosis	Johne's disease	Can be fatal, affects intestinal tract	No
NEMATODES (Roundworms)			
Elaphostrongylus cervi	Tissue worm	Affects central nervous system and thoracic muscle tissue	No
Parelaphostrongylus tenuis	Meningeal brain worm	Fatal neurological disease	No
Parelaphostrongylus odocoilei	Muscle worm	Non-fatal, affects loin and thigh muscle	No
TREMATODES (Liver flukes)			
Fascioloides magna	Giant liver fluke	Generally non-fatal, liver cysts	No
CESTODES (Tapeworms)			
Echinococcus granulosis	Hydatid disease		No
Taenia hyatigena			No
Taenia krabbei			No
ARTHROPODS/ECTOPARASITES			
Cephenemyia trompe	Bot fly	Non-fatal skin infestation	No
Dermacenter albipictus	Moose tick	Fatal if heavy tick load	Yes [2]
Oedemagena tarandi	Warble fly	Non-fatal skin infestation	No
Culicidae	Mosquito	Rarely fatal in neonates	Yes
Simuliidae	Black fly	Rarely fatal in neonates	Yes
Tabanidae	Horse fly, Deer fly	Non-fatal	Yes

1 Found in barren-ground caribou wintering in Saskatchewan (Wobeser 1985)
2 Montreal Lake (Trottier 1988a)

4.5.3 Abiotic Factors

The role of winter snowfall, snow density, and persistence in spring affects caribou survival. Calf survival is generally lower in years of late snowmelt (Adams 2003, Adams et al. 1995, Bergerud and Elliot 1986, Bergerud and Page 1987). Snow depth, extent of snow crusting, frequency of snowstorms, and winter temperatures synergistically influence winter survival (Trottier 1988a).

4.5.4 Hunting

Woodland caribou can be harvested for subsistence purposes. Subsistence hunting does not appear to be widespread in Saskatchewan, but may be locally important where access is convenient and a caribou hunting tradition is present (Trottier 1988a). This is because most subsistence hunters prefer moose and deer relative to caribou, and therefore tend to be opportunistic caribou hunters (Trottier 1988b).

From 1947 through 1961 there was no licensed hunting for woodland caribou (Rock 1988). From 1962 through 1986 there was a licensed hunting season, but during the latter part of this period a series of restrictions were introduced to protect a perceived decline in hunter success and population size (Rock 1988). Annual harvest was small (about 85 caribou/yr), with most of the caribou harvested opportunistically by moose hunters. Licensed hunting was terminated in Saskatchewan in 1987 (Rock 1988).

Sustainable harvests are a dynamic metric related to ungulate density (Caughley (1976). At extremely low densities, sustainable harvest levels are nil or very limited because of low stocks and limited ability of caribou to compensate. Hunting is an additive factor in caribou population dynamics (Rock 1992). Caribou are quite susceptible to hunting due to their lack of wariness of people, curiosity, frequent occupation of fairly open peatland habitats, and frequent response of running to open areas when disturbed (B. Wynes, personal comm.). Boreal caribou populations that coexist with wolves will decline if harvest by humans exceeds 5% (Bergerud 1974).

4.6 Competition

No information could be found describing or investigating intra- or inter-specific competition in woodland caribou.

4.7 Ecological Role/Significance

Woodland caribou are the only major ungulate in North America specifically adapted to life in mature, lichen-rich, coniferous forests (Kelsall 1984). Woodland caribou are vulnerable to habitat change because of their dependence on large areas of undisturbed climax habitat and lichens (Gray 1999), and fragility with respect to even minor changes in population limiting factors. They are the only native Saskatchewan cervid that naturally occurs at low densities, and whose status is threatened. Because of the fragile and sensitive nature of this species, they are considered an indicator species for health of old-growth forests. Conservation of boreal caribou is necessary to maintain biodiversity in the boreal forest (Thomas and Gray 2001).

5.0 Status and Management

5.1 Population Status

Increasing risk of population extinction with decreasing population size is well established in both theoretical and empirical literatures (Hanski 2002). Small populations tend to have a higher extinction rate than larger ones regardless of the mechanism of extinction (Hanski 2002).

The low reproductive rate and high mortality rate of newborn calves results in a low potential rate of population growth. Consequently, woodland caribou populations are extremely vulnerable to various sources of mortality, including predation, hunting, disease, parasites, accidents, etc. (Cumming 1992). Boreal caribou are viewed as a fragile species because of it's dependence on mature boreal forests and limited resilience to direct and indirect factors limiting populations as a consequence of resource extraction activities (Edmonds 1988, Edmonds 1991). Management favoring caribou populations is not compatible with management practices that favor higher density moose and/or deer populations on the same land base because of issues of habitat alteration, increased predation, and other factors already discussed that limit caribou populations.

5.1.1 International Status

Boreal caribou are virtually endemic to Canada (Thomas and Gray 2001). The Nature Conservancy global rank for caribou is G5, which signifies the species is demonstrably widespread, abundant and secure. However, the woodland caribou sub-species is listed as endangered in the United States. In Canada, woodland caribou ranks vary by provincial jurisdiction from SX (extirpated) to S5 (widespread, abundant, secure), S3 (12 March 1993, Saskatchewan Conservation Data Center) in Saskatchewan (Gray 1999).

5.1.2 National Status

The western population of woodland caribou *(Rangifer tarandus caribou)* was designated "rare" at the national level by COSEWIC (Committee on the Status of Endangered Wildlife in Canada) in 1984. COSEWIC renamed this designation category to "vulnerable" in 1995 (see COSEWIC's website: www.cosewic.gc.ca). The status of Boreal Caribou was reviewed in a report presented to COSEWIC by Gray (1999), who recommended a change in national status from "vulnerable" to "threatened", to reflect a greater level of endangerment. This was done by COSEWIC in May 2000 (Thomas and Gray 2001). The change of designation to "threatened" at the national level resulted in a series of reports by individual provincial jurisdictions, to assess the status of woodland caribou at the provincial scale (Dzus 2001, Godwin and Thorpe 2000, Rebizant et al. 2000).

5.1.3 Provincial Status

The cumulative effects of habitat fragmentation and alteration (progressive timber harvest, land clearing for agriculture, large-scale access development, linear corridor development, resource exploration and development), shifts in range of white-tailed deer and moose, shifts in predator/prey equilibrium, wildfire, and hunting have all contributed to population decline, range contraction, and population fragmentation of woodland caribou on the boreal plain ecoregion. The direct and indirect effects of these population-limiting factors are less pronounced in the boreal shield ecoregion primarily because of the relatively limited human related impacts. Saskatchewan's status report

recommended a "threatened" designation provincially because of observations of elimination of individual woodland caribou bands, indication of population declines in the mid-boreal ecoregion concurrent with logging (Rettie et al. 1998), mining, and associated road development, as well as expansion of the forest industry under current government policy (Godwin and Thorpe 2000). Trottier (1988b) noted a progressive decline in mean group size over 3 decades, and suggested that habitat fragmentation concurrent with increased human activity, was resulting in fragmentation of caribou populations and overall population decline. Trottier (1988b) and Rock (1992) both attributed declines in woodland caribou directly to commencement of logging activities.

Several authors have estimated the current boreal caribou populations in Saskatchewan to range from 2,500 animals (Bergerud 1980b, Ferguson and Gauthier 1992, Gray 1999, Kelsall 1984, Rettie et al 1988) to 5,000 animals (Godwin and Thorpe 2000).

5.2 Population Dynamics

To effectively manage an ungulate species, it's population dynamics must be thoroughly understood. Changes in habitat structure, quality, and/or quantity indirectly influences survival and reproduction of an animal. In population ecology, direct and indirect factors that limit a population (eg. habitat quality, habitat quantity, mortality variables, reproductive potential, etc.) are inter-related. Boreal caribou naturally occur at low densities and have a low reproductive output. Consequently, they have difficulty coping with the effects of limiting factors (acting independently or synergistically) compared to other higher density/more productive ungulate species, particularly if one or more of those factors changes in intensity. Small changes in population dynamics can have significant consequences on the long-term viability of a caribou population (Dyer et al. 2001).

The reproductive rate of caribou is low compared to other cervids because females do not reach puberty until 28 months, and often as late as 40 months of age (Bergerud 1974). By contrast, moose and elk can breed as yearlings. Also, caribou typically have only one calf, whereas other cervids frequently have twins (Bergerud 1974). This, coupled with low calf recruitment due to the high mortality rate of calves resulted in a low population growth rate, and population sensitivity to factors affecting survival.

Bergerud (1974) proposed that caribou populations with >15% calves in late winter/spring were increasing, those with 12-15% calves in late winter/spring were stable, and those with <10% calves were likely declining. Stuart-Smith et al. (1997) reported a population with annual adult survival of 0.88 and low calf survival (9% of spring population) to be in gradual decline. Variability in juvenile survival plays a critical role in cervid population dynamics (Gaillard et al. 1998). Dzus (2001) reported variable calf survival ranging from 10-40% in northern Alberta during the 1990s, and indicated that annual adult survival must be >85% to have a positive population growth rate. McLoughlin et al. (2003) confirmed the same findings as Dzus (2001).

Rettie and Messier (1998) reported an annual adult survival rate of 84% for the Smoothstone-Wapaweka meta-population in Saskatchewan. They also reported a 94% pregnancy rate, with an 86% parturition rate, which indicated adequate nutrition. However, calf recruitment was typically low at 28 calves/100 cows, which they attributed to wolf and possibly bear predation. They assessed this meta-population to consist of several spatially disjunct populations, in decline. The population decline since 1970 was directly attributed to expansion of road construction and logging since 1966, and related proximate causes including hunting pressure (prior to 1987), increased predation, and possibly severe winter conditions.

5.2.1 Population Density

Table 4 summarizes estimated size of each Saskatchewan woodland caribou meta-population in relation to their range, as defined by Figure 2. Table 5 summaries caribou densities from other jurisdictions.

Table 4. Summary of woodland caribou meta-population size and density by Woodland Caribou Management Unit (WCMU).

WCMU	Range (km²)	Survey Year	Survey Area (km²)	Geographic Area	Population Density (#/km²)	Source	Estimated Population Size
Davy–Athabasca	31,870	---	---	West Athabasca Plain ecogregion	0.008	Godwin and Thorpe (2000)	240 [a]
Highrock–Key	43,611	1979	9,000	Key Lake	0.030	Beak Consultants Ltd. (1979)	1,788 [b]
		1987	697	Cigar Lake	0.030	Beak Assoc. Consulting Ltd. (1988)	
		Jan 1988	2,380	Key Lake	0.043	Brewster (1988)	
		1989	1,656	Island Falls – Points North	0.033	Beak Assoc. Consulting Ltd. (1989)	
		Jan 1992	2,380	Key Lake	0.039	Trottier (1994)	
Steephill–Foster	42,194	1989	1,656	Island Falls – Points North	0.033	Beak Assoc. Consulting Ltd. (1989)	1,392 [c]
Primrose	32,225	Jan 1991	390	Muskeg Lake, Air Weapons Range	0.041	Rock (1992)	350 [a]
		Jan 1991	285	White Gull Lake	0.053	Rock (1992)	
		---	---	Primrose Lake	0.011	Godwin and Thorpe (2000)	
Smoothstone - Wapaweka	48,870	1960	672	West of Sled Lake	0.137	Ruttan (1960)	350 [a]
		Dec 1986	2,400	Weyakwin	0.024	Rock (1988)	
		Jan 1987	718	Sled Lake	0.038	Rock (1992)	
		Dec 1990	3,990	P.A.N.P.	0.020	Rock (1992)	
Suggi–Amisk	24,872	Jan 1987	1,080	Hanson Lake	0.050	Rock (1992)	100 [a]
		Jan 1987	920	Attiti Lake	0.059	Rock (1992)	
Pasquia–Porcupine	6,825	---	---	---	0.003	Godwin and Thorpe (2000)	20-40 [a]
WCMU Total	230,465						4,250

[a] Godwin and Thorpe (2000) estimates for mid 1990s.
[b] Range area x 0.041 caribou / km²
[c] Range area x 0.033 caribou / km²

Table 5. Summary of woodland caribou population densities in other jurisdictions.

Survey Year	Survey Area (km²)	Geographic Area	Population Density (#/km²)	Reference
Winter 1976-78	1,400	Birch Mountains - NE Alberta	0.042	Fuller and Keith (1981)
1991-94	2,427	Athabaska River - NE Alberta	0.077	Stuart-Smith et al. (1997)
Winter 1979-1983	---	Alberta foothills	0.030	Edmonds and Bloomfield (1984)
Winter 1974	235	SE Manitoba	0.153	Stardom (1975)
Winter 1978-81	2,824	Lake Nipigon, Ontario	0.071	Cumming and Beange (1987)
1975 - 1985	---	Quebec and Labrador	0.030	Brown et al. (1986)

Caribou populations in forested habitats are very difficult to reliably and precisely inventory because of their cryptic coloration and natural occurrence at very low population densities. Woodland caribou population densities are variable but low (relative to other cervid populations) throughout their North American range. At the landscape level, boreal caribou require a perpetual supply of large contiguous area of suitable summer and winter habitat, with little or no vehicle access or disturbance, so they can space out at low densities (0.03-0.05 caribou/km^2), and thereby avoid predators (Bergerud 1992, Seip 1992).

5.2.2 Population Structure

Adult sex ratio is variable across boreal caribou range. This metric is measured in winter as a proportion (% adult males or adult females of population) or as a ratio (bulls/cow or bulls/100 cows), and is used to assess the status of the breeding population. Adult sex ratios have been reported in several studies (Tables 6 and 7) and normally are about 35% males (Bergerud 1980a, Edmonds 1988, Fuller and Keith 1981).

Table 6. Woodland caribou winter population structure reported from studies in adjacent jurisdictions.

Geographical Area	Survey Year	Winter Population Structure					Source
		Bulls /Cow	Calves /Cow	% Bulls	% Cows	% Calf	
NE Alberta	1991-94	0.84	0.52	36	42	22	Stuart-Smith et al.(1997)
NE Alberta	1976-78	0.85	0.26	41	47	12	Fuller and Keith (1981)
West-central Alberta	1981-86	0.54	0.27	30	55	15	Edmonds (1988)
Alberta Foothills	1979-93	0.55	0.36	29	52	19	Edmonds and Bloomfield (1984)
Central Manitoba	1995	0.50	0.65	23	47	30	Brown et al (2000)

Table 7. Structure of woodland caribou populations surveyed in Saskatchewan.

WCMU	Survey Year	Winter Population Structure						Source
		Bulls /Cow	Calves /Cow	% Bulls	% Cows	% Calf	n	
Highrock-Key	Jan 1988	0.53	0.32	29	54	18	63	Brewster (1988)
	Jan 1992	0.38	0.54	20	52	28	50	Trottier (1994)
Suggi-Amisk	Jan 1987	0.60	0.10	35	59	6	17	Attiti Lake Survey
	Jan 1987	0.33	0.33	20	60	20	45	Hanson Lk Survey
Smoothstone-Wapaweka	Dec 1986	0.33	0.27	24	60	16	55	Weyakwin Lake Survey

Calf recruitment refers to the number of calves that survive to become adults and enter the breeding population. This metric is generally measured in late winter as a proportion (% calves of population) or as a ratio (calves/cow or calves/100 cows). Calves generally make up about 30% of the population at birth, but by recruitment age (one year old) they usually represent <20% of the population because of high mortality (Tables 6 and 7). Boreal caribou populations are considered stable if calves represent 15% of the population, or are increasing if calves represent >15% of the population. However, this is also contingent on adequate adult survival (>85% annual survival).

Recruitment rates are highly variable in ungulate populations, which suggest that factors affecting juvenile survival are important to population dynamics (Gaillard et al. 1998). Populations with a female biased sex ratio and young male age structure can result in delayed conception and/or reduced conception rates, which have the effects of delayed calving, asynchronous calving and

lowered calf production (Holand et al 2003). Late calving could reduce future fertility of females. Late born calves and asynchronous calving result in increased calf mortality and reduced recruitment (Holand 2003).

5.2.3 Group Size

Group size is highly variable (Table 8). Adult bulls are solitary from May through August whereas cows are seldom without other adults and/or a calf during the same period (Fuller and Keith 1981). Pregnant cows become solitary immediately prior to parturition (May), but dry cows remain with other individuals. Both adult bulls and cows begin to form mixed herds for the October rut (Fuller and Keith 1981). From December through April, bulls generally associate in bachelor herds, while cows (with and without a calf) generally form small groups with other cows and young bulls. Group sizes tend to be smaller in summer and larger in winter. Provincially, mean group size in Saskatchewan between the 1970s and 1980s had declined from 6.1 (n=311) to 4.6 (n=1,263) (Rock 1992, Trottier 1988b). Caribou groups (bands) probably represent distinct social units within a larger herd (Trottier 1988b).

Table 8. Comparison of group size by season and jurisdiction.

Mean Group Size					
Summer	Winter	Annual	Geographical Area	WCMU	Source
---	---	11.1 (1960–69) 6.1 (1970-79) 5.3 (1980-84) 4.3 (1985-87)	East-central Saskatchewan		Trottier (1988b)
---	4.2	---	Prince Albert Natl. Park	Smoothstone-Wapaweka	Burles et al. (1978)
---	4.3	---	Weyakwin Lake, Sask.		Rock (1988)
---	6.8	---	Attiti Lake, Sask.	Suggi-Amisk	Rock (1988)
---	5.6	---	Hanson Lake, Sask.		Rock (1988)
---	3.7	---	Key Lake, Sask.	Highrock-Key	Brewster (1988)
---	4.8	---	Key Lake, Sask.		Trottier (1994)
1.2	5.4	---	NE Alberta		Fuller and Keith (1981)
1.9	6.5		West-central Alberta		Edmonds (1988)
1.9	6.5	---	Alberta foothills		Edmonds and Bloomfield (1984)
1.2	5.5	---	SE Manitoba		Darby and Pruitt (1984)
1.8	4.5	---	Central Manitoba		Brown et al. (2000)
1.7	4.6	2.5 (1974)	Central Manitoba		(Shoesmith and Storey (1977)
---	8.6	---	Lake Nipigon, Ontario		Cumming and Beange (1987)

5.2.4 Maintenance of Genetics

Maintenance of genetics is particularly important to populations that are fragmented and/or isolated. Barriers to gene flow will result in long-term deleterious effects on populations. Matings between related individuals tend to reduce offspring viability and fertility because of increased chances of creating homozygous expression of recessive deleterious genes, commonly known as inbreeding depression in biological fitness (Lande 2002). Deleterious genes may affect the recovery of a small population, but may have already been purged during population decline (Lacy 1997)

6.0 Management Approaches

6.1 Coarse Scale / Ecosystem-based Management

Ecosystem-based management is a landscape planning approach to natural resource management with the intention of maintaining biodiversity and ecosystem integrity while integrating economic and social objectives (Haufler et al. 2002). Any process which fragments the landscape, restricts caribou movement, and/or makes caribou more spatially and temporally predictable, can result in increased vulnerability to mortality (Dyer 1999, Seip 1991). Sustainable woodland caribou populations require maintenance of range occupancy at natural levels of abundance within a managed boreal forest landscape.

Ecosystem-based management at the **landscape level** relates to the mix of ecosystems occurring in the planning landscape used by woodland caribou relative to the mix that occurred under historical disturbance regimes. It may be possible for industry to emulate natural disturbance patterns on the landscape, provided the activity can assure conservation of structure and function of the affected forest ecosystems (Euler 1998). At the **ecosystem (stand) level**, each ecosystem used by woodland caribou can be assessed on the basis of composition, structure, function and process relative to historic caribou range. At this level, industrial activities that impact habitat could be influenced by quantitatively incorporating wildlife (including caribou) habitat attributes within the management framework that habitat is altered by industry (eg. timber management in commercially forested areas). The spatial scales and temporal periods over which habitat alteration by industry occurs, should match the scales and periods of habitat use by caribou and other wildlife species (Keppie 1995, Rempel et al. 1997). Contemporary habitat models are mostly descriptive and of limited use for wildlife management because they do not facilitate predictions of wildlife population changes over particular temporal periods and continually changing spatial arrangements of forest structure (Keppie 1995). At the **species level**, the viability and population parameters for caribou in the planning landscape can be related to the same measures in historic range, to assess and ameliorate industry impacts.

6.2 Fine Scale / Population Management

The key component of all wildlife population studies is to understand population dynamics by determining whether populations are increasing, decreasing, or stable over time. It is also important to understand the mechanism(s) influencing population status. The fine scale approach is required for any wildlife species or population that is not limited by habitat, but is limited by other factors such as hunting, or increased mortality as a consequence of direct or indirect human effects on the landscape. Management of boreal caribou requires weighing the risks or threats of various population limiting factors, with conservation needs.

To address this conservation focus, both a management-by-objective (MBO) approach and an adaptive management (AM) approach can be used. An MBO approach is accomplished through a planned management system (Arsenault 1998, Arsenault 2000, Arsenault 2003, Strickland 2001). This includes inventory of managed resources through area specific collection and assessment of population and habitat metrics, identification of management goals and objectives, management actions, and evaluation of the response of resources to management (Strickland 2001). MBO Is typically adaptive in that evaluation may lead to changes in any component within the planned management system (Strickland 2001). Management actions can be structured in an adaptive management frame (Walters and Holling 1990) to learn from, and improve future management/conservation actions within ecosystem-based management principles.

7.0 Risk Assessment by WCMU

The challenge for caribou conservation is to maintain sufficient quantities and distribution of suitable habitat through time, in each WCMU (Figure 3), whilst avoiding extirpation of local caribou populations by increasing the direct or indirect effects of population limiting factors.

Table 9. Risk assessment by WCMU based on potential population limiting factors.

Woodland Caribou Management Unit (WCMU)	Potential Population Limiting Factors	Risk Level
Derry-Athabasca	▸ Unknown – data deficient	Low
Highrock-Key	▸ Hunting mortality from subsistence use ▸ Disturbance related to heavy metal mining ▸ Increased access from mineral exploration, transportation corridors, utility (power, phone) corridors	Medium
Steephill-Foster	▸ Hunting mortality from subsistence use ▸ Access/linear development	Low
Primrose	▸ Habitat fragmentation from oil and gas industry ▸ Habitat loss from agriculture and forest grazing in southern portion ▸ Recreational activities in southern portion ▸ Small meta-population (est. 350 animals per Arsenault 2003)	Medium
Smoothstone-Wapaweka	▸ Habitat Fragmentation (logging) ▸ Access (trails, roads, power corridors, seismic lines) ▸ Disturbance (recreation, logging) ▸ Hunting mortality (subsistence use) ▸ Habitat loss (agriculture along southern fringe, forest grazing in west side, logging) ▸ Fragmented populations ▸ Small meta-population (est. 350 animals per Arsenault 2003)	High
Suggi-Amisk	▸ Habitat fragmentation (logging) ▸ Planned expansion of forest industry onto Boreal Shield portion of range ▸ Access (trails, roads, power corridors, seismic lines) ▸ Disturbance (recreation, logging) ▸ Hunting mortality (subsistence use) ▸ Small meta-population (est. 100 animals per Arsenault 2003)	High
Pasquia-Porcupine	▸ Habitat loss and fragmentation (peat mining, agriculture, logging) ▸ Fragmented populations inhabiting habitat islands surrounded by agricultural lands. ▸ Access (trails roads (proposed upgrade of Fir River Road to all weather status), seismic lines) ▸ Disturbance (high level of recreation (skidooing, hunting, ATV use), outfitting and trapping, because of high level of access from logging) ▸ Large predator (bear, wolf) populations because of large alternate prey populations (moose, elk, white-tailed deer). ▸ Hydro-electric dams (E.B. Campbell Dam (1967) and Francois-Findley Dam (1985)) may have resulted in habitat loss and fragmentation, resulting in isolation and loss of southern populations from this WCMU. ▸ *P. tennuis* has been diagnosed in moose in this WCMU (Arsenault 2000) ▸ Small meta-population (est. 20 – 40 caribou per Arsenault 2003)	High

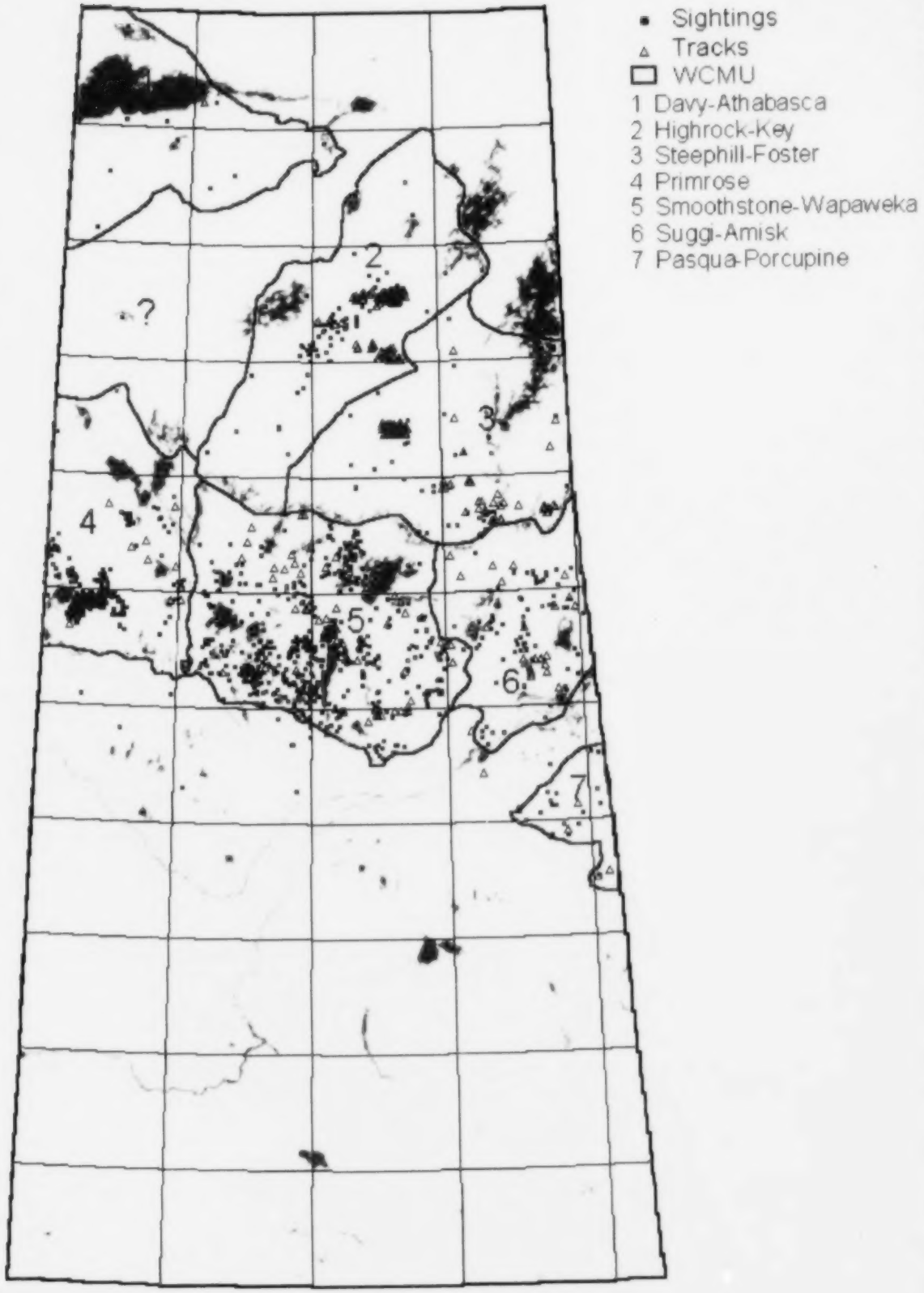

Figure 3. Woodland caribou management units (WCMUs).

8.0 Recommendations

The following are recommendations and considerations for development of a provincial woodland caribou recovery plan. Implementing these recommendations will only be effective if there is commitment to boreal caribou conservation from government, industry and Saskatchewan residents. A collaborative approach by government, industry and Saskatchewan residents is required to maintain caribou in perpetuity.

8.1 Policy Framework

Saskatchewan Environment's corporate mandate is to manage, enhance and protect Saskatchewan's natural and environmental resources (fish, wildlife, forests, lands, parks and protected areas, air, water, and soil) for conservation, recreation, social and economic purposes, and to ensure they are sustained for public benefit and for future generations.

The **Fish and Wildlife Policy Framework** defines the principles of ecosystem-based management, which currently defines the policies and direction within which programs are developed, delivered and integrated.

First Nations, Metis, industry, other agencies, and stakeholders have an interest, expertise, and resources to devote to woodland caribou management and recovery planning. Industry has a specific responsibility (requirement of doing business on the landscape) to be actively involved in caribou conservation and research. Other agencies, stakeholders, First Nations and Metis have a responsibility of sharing local knowledge and active participation in caribou conservation.

8.2 Population Management

A recovery plan should determine whether the population objective(s) for a particular WCMU is for "survival" or "recovery". A viable population has several characteristics including:

- Self-sustaining under natural or managed conditions with a high likelihood of persistence. The IUCN (International Union for Conservation of Nature and Natural Resources) define population viability as a 90% probability of persistence over a 100 year time period. This time interval represents 7-8 caribou generations.
- Viable populations should have opportunities for dispersal, be well distributed over its range (multiple populations) and resistant to stochastic events.
- Viable populations should have a healthy population structure (age structure and sex ratio) occurring at a natural level of abundance (density), and with adequate demography (survival rates, fecundity and dispersal rates).

A prudent strategy is to maintain multiple populations. If the unit of focus is the species in each of the ecological settings it originally occupied, then objective is to have several such populations in each setting as a hedge against catastrophic loss. The management strategy should ensure that each population is large enough so that the population is not swamped by the effects of demographic uncertainty and/or short-term inbreeding. Shaffer et al. (2002) recommend populations need to be large enough so that they can respond to good environmental conditions when they happen, and not be trapped in demographic or genetic vortices that result from very low numbers.

Because of sedentary nature of woodland caribou, conservation efforts for populations at high risk should focus on the need to preserve ranges presently used by caribou bands, and maintain them in predator sparse habitats.

Continued effort is necessary to continually update and monitor caribou range and areas of current occupancy in relation to potential range, and/or unoccupied range. This effort should also include documentation of known movement corridors, seasonal distribution, and calving sites. This data would be useful to define areas where woodland caribou conservation takes first priority.

8.3 Habitat Management

A woodland caribou recovery plan would be largely focused on habitat conservation and management. The following should be considered in development of habitat management strategies in the provincial recovery plan:

- Mitigate large functional habitat degradation by reducing the level of disturbance and minimizing the human footprint on the landscape (Dyer 1999).

- An access management plan should be developed for boreal caribou range, in collaboration with interest groups (MacDonald 2001). This would require an inventory of existing access corridors, and planned future development. Where feasible, right-of-way widths should be reduced to minimize barrier effects. Road and trail network development along main haul roads should be minimized.

- Access in woodland caribou range via "low standard" temporary roads on frozen ground should be encouraged over "summer standard" roads that create long term access and habitat fragmentation.

- Habitat types that are extensively used by caribou, and consistently selected in preference to alternative habitat types, should be avoided by industrial development. Habitat types that are consistently avoided by caribou may provide suitable locations for industrial infrastructure. Temporal scale must be considered (seasonality of habitat use, age class of habitat type). Spatial scale and fragmentation are important planning considerations to maintain a natural pattern of forest habitat patch size, cover type and age class structure, whilst avoiding creation of a matrix of young and old (but little mid-aged) forest.

- Industrial activity in caribou range should avoid treed peatland areas throughout the year, to reduce caribou disturbance. Utilizing upland areas within caribou range will likely minimize direct disturbance to caribou.

- Hydrologic changes (water levels and flow patterns) to a peatland complex can affect lichen survival in treed peatlands (treed bogs and treed fens). Therefore, industrial influences on hydrology should be a consideration on the planned landscape.

- Timber harvest planning on woodland caribou range should retain sufficient area to support viable caribou populations at characteristic densities (Smith 2000).

- Since caribou do not use areas of active timber harvest, habitat fragmentation could be minimized by localizing timber harvest in time and space (Smith 2000). Activity should be concentrated in one portion of range rather than distributing the activity (disturbance) through a population's range.

- Timber harvesting in defined areas of occupied caribou core areas should be avoided in the short term. If this is unavoidable, then blocks should be cut to minimize edge effect and mimic a large-

scale fire pattern and to provide future caribou habitat. Cut blocks should maintain a more natural pattern of patch size and shape and result in a natural age class distribution of forest in the long-term.

- In areas where old growth forest values are limited, selective cutting should be used as an alternative to clear cutting as a means of maintaining age class distribution objectives, and to maintain habitat structure at the landscape scale. Edmonds and Bloomfield (1984) recommended a 3- pass system (50 yr intervals), with narrow (<150m wide) cut blocks to maintain a minimum forest age of 100 years in areas of current woodland caribou use.

- A conservative approach should be used for timber harvest planning around fen/bog complexes occupied by caribou (James 1999).

- Timber management should be planned to avoid creating barriers (eg. large cut-over areas, prolonged road access) between wintering ranges and critical sites (eg. known calving areas, movement corridors). Timber management practices in occupied caribou habitat must be conducted in a manner which supports forest stands capable of producing lichens on suitable sites, discourages fragmentation of forest cover in winter habitats, and avoids population growth/concentration of alternative prey species (Godwin 1990).

- Timber management in caribou range should be planned to conserve (appropriate amounts) the key attributes of mature forests, to make them less suitable for alternate ungulate species, thereby reducing predation risk. Forest management must focus planned harvest so that it will produce appropriate amounts of old growth forest 80-100 years into the future.

- Identify habitat changes in each WCMU resulting from wildfire, and land use activities (including planned changes from future potential activities).

- Develop WCMU-specific woodland caribou management strategies that integrate resource extraction management plans, access management (both for resource extraction and exploration), and predator/alternate prey management (where artificial habitat alteration affects predator and alternate prey populations).

- Define areas where woodland caribou conservation takes first priority.

8.4 Research Needs and Management Focus

- Future research should focus on evaluating the cumulative effects of industrial development. Cumulative effects thresholds must be developed and incorporated into management of caribou ranges as part of a comprehensive strategy to integrate caribou conservation and human activity on a common land base (Dzus 2001).

- Research and monitoring programs in an adaptive management framework should be used to review and evaluate and modify government and industry policies, practices and programs that limit caribou conservation. Develop and rigorously implement land use guidelines that address research findings (Dzus 2001)

- Research needs depend primarily on what information is on hand, and the priorities assigned to management among various caribou populations (Kelsall 1984).

- Assess the effectiveness of applied strategies and modify strategies in response to effectiveness of previous prescriptions (adaptive management).

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